Supporting Information

Radical-Pair Based Magnetoreception Amplified by Radical Scavenging: Resilience to Spin Relaxation

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Table S1: Hyperfine parameters of the model systems used in this study. These hyperfine tensors are identical to those used in reference [1]. See [2] for a detailed description of their derivation.

FAD$^{\bullet-}$	
N5	$A_{N5} = \begin{pmatrix} -2.77 & 0.11 & 0 \\ 0.11 & -2.47 & 0 \\ 0 & 0 & 49.24 \end{pmatrix}$ MHz
N10	$A_{N10} = \begin{pmatrix} -0.53 & -0.13 & 0 \\ -0.13 & -0.55 & 0 \\ 0 & 0 & 16.94 \end{pmatrix}$ MHz
H6	$A_{H6} = \begin{pmatrix} -7.20 & -3.57 & 0 \\ -3.57 & -13.20 & 0 \\ 0 & 0 & -12.15 \end{pmatrix}$ MHz
3 × H8	$A_{H8} = \begin{pmatrix} 12.33 & 0 & 0 \\ 0 & 12.33 & 0 \\ 0 & 0 & 12.33 \end{pmatrix}$ MHz
2 × Hβ	$A_{H\beta} = \begin{pmatrix} 11.41 & 0 & 0 \\ 0 & 11.41 & 0 \\ 0 & 0 & 11.41 \end{pmatrix}$ MHz
$W_C^{\bullet+}$	
N1	$A_{N10} = \begin{pmatrix} -0.94 & 2.59 & -3.79 \\ 2.59 & 9.26 & -14.90 \\ -3.79 & -14.90 & 18.72 \end{pmatrix}$ MHz

1. D. R. Kattnig and P. J. Hore, *Sci. Rep.*, 2017, **7**, 11640.
2. A. A. Lee, J. C. S. Lau, H. J. Hogben, T. Biskup, D. R. Kattnig and P. J. Hore, *J. R. Soc. Interface*, 2014, **11**, 20131063.

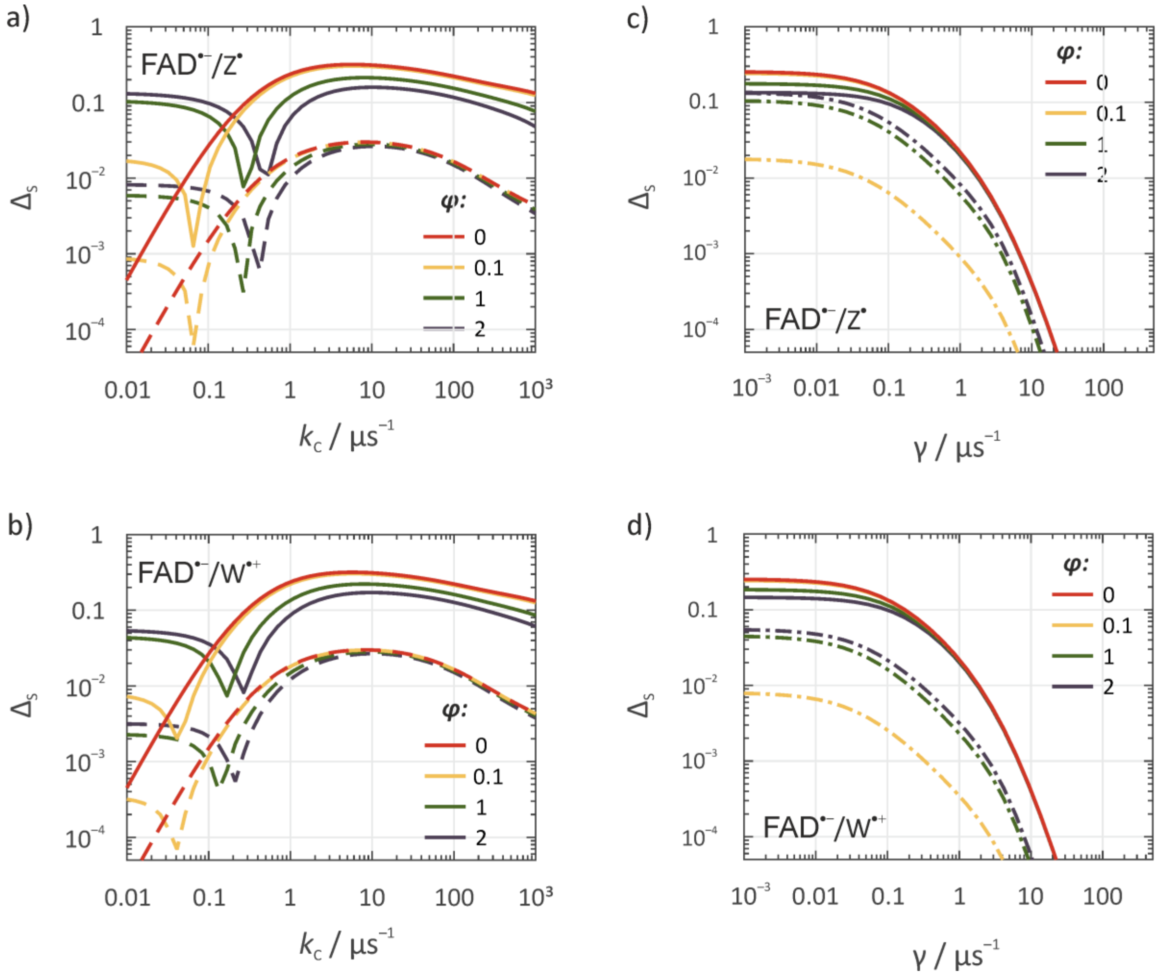

Figure S1: Absolute reaction anisotropy as a function of k_C or γ. Panels *a) and b)*: Dependence of Δ_S on k_C in the absence (solid lines) and presence (dashed lines) of spin relaxation with $\gamma = \gamma_A = \gamma_B = \gamma_C = 1\ \mu s^{-1}$ for various $\varphi = k_b/k_f$ as encoded by the different colours and summarized in the common legends. Panels *c) and d):* Dependence of Δ_S on $\gamma = \gamma_A = \gamma_B = \gamma_C$ for $k_C = 51.8\ \mu s^{-1}$ (solid lines) and $k_C = 0\ s^{-1}$ (no scavenging, dashed-dotted lines). All calculations are based on a spin system comprising N5 and N10 of $FAD^{\bullet-}$ in $A^{\bullet-}$ and no hyperfine coupled nuclei in $C^{\bullet}$. For panels *a)* and *c)* no hyperfine coupled nuclei are present in $B^{\bullet+}$ ($FAD^{\bullet-}/Z^{\bullet}$ model); for panels *b)* and *d)* N1 of $W^{\bullet+}$ has been included ($FAD^{\bullet-}/W^{\bullet+}$ model). See Figure 2 of the main manuscript for additional details.

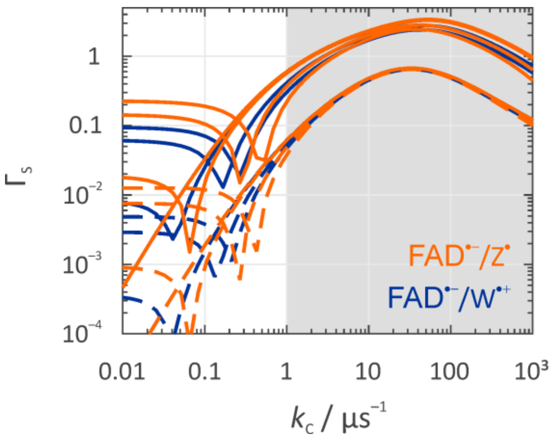

Figure S2: Overlay of the data from Figure 2a and 2b. The plot gives the relative anisotropy as a function of k_C for the FAD$^{\bullet-}$/Z$^{\bullet}$ (orange lines) and the FAD$^{\bullet-}$/W$^{\bullet+}$ (blue lines) model in the absence (solid lines) and presence (dashed lines) of relaxation for four different values of φ. Refer to the caption of Figure 2 for details. Under conditions of significant radical scavenging (region shaded in grey) the relative anisotropies are nearly unaffected by the identity of B$^{\bullet+}$.

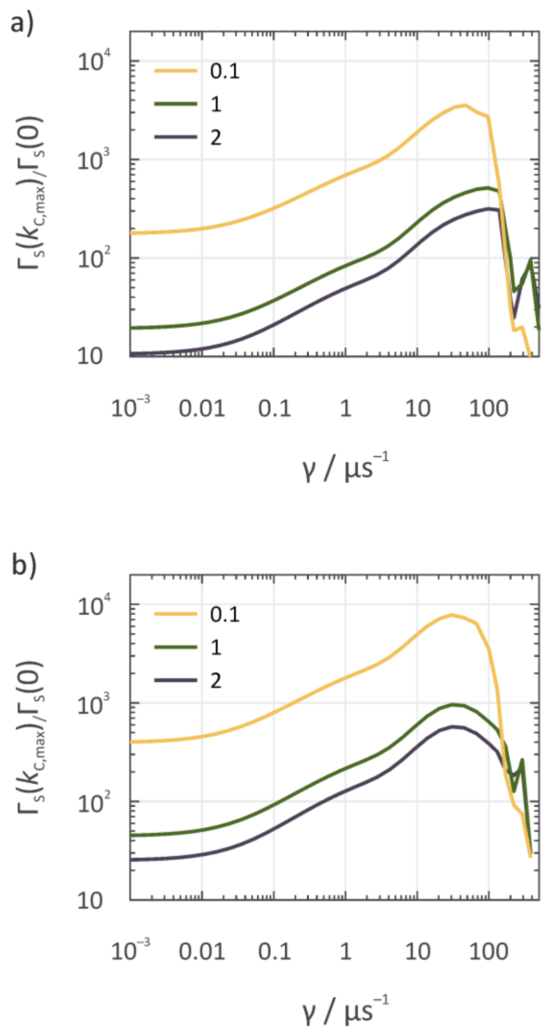

Figure S3: Ratio of the relative anisotropy Γ_s of the signalling state in the presences and absence of radical scavenging, $\Gamma_s(k_C{=}51.8\ \mu s^{-1})/\Gamma_s(k_C{=}0)$, as a function of the relaxation rate γ for various $\varphi = k_b/k_f$ (as encoded by the different colours and summarized in the legend) for a) the $FAD^{\bullet-}/Z^{\bullet}$ and b) the $FAD^{\bullet-}/W^{\bullet+}$ model. Random field spin relaxation was present in all radicals: $\gamma = \gamma_A = \gamma_B = \gamma_C$. B_0 = 50 µT and k_f = 0.1 µs^{-1}.

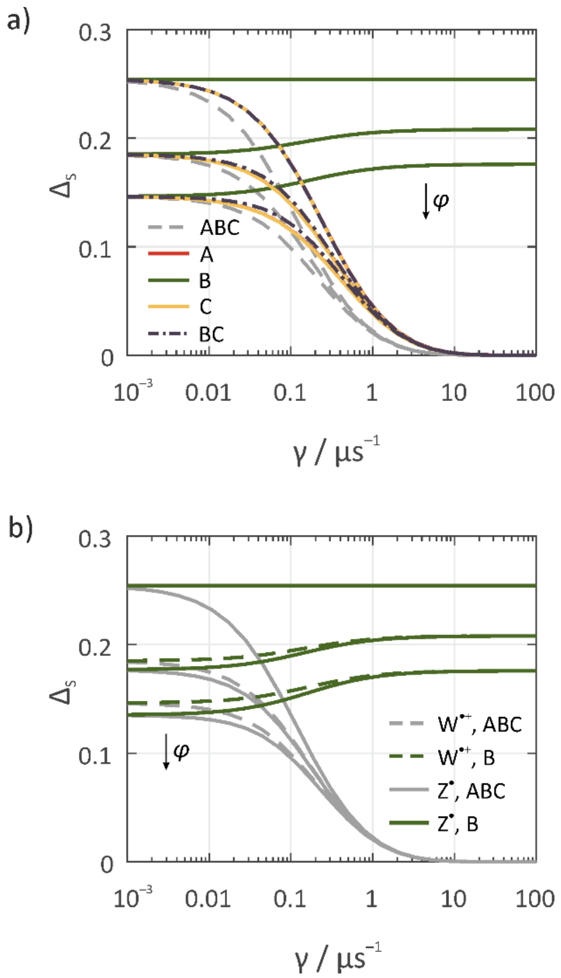

Figure S4: Dependence of Δ_S on the rate of random-field spin relaxation in chosen parts of the three-radical system for $\varphi = k_b/k_f$ = 0, 1, and 2. Panel *a)* applies to the scavenged $FAD^{\bullet-}/W^{\bullet+}$ scenario. In panel *b)* the $FAD^{\bullet-}/W^{\bullet+}$ model is compared to the $FAD^{\bullet-}/Z^{\bullet}$ model. The legends name the radicals that are impacted by spin relaxation. k_C = 51.8 μs^{-1}. Further details are available from the caption of Figure 3 of the main document.

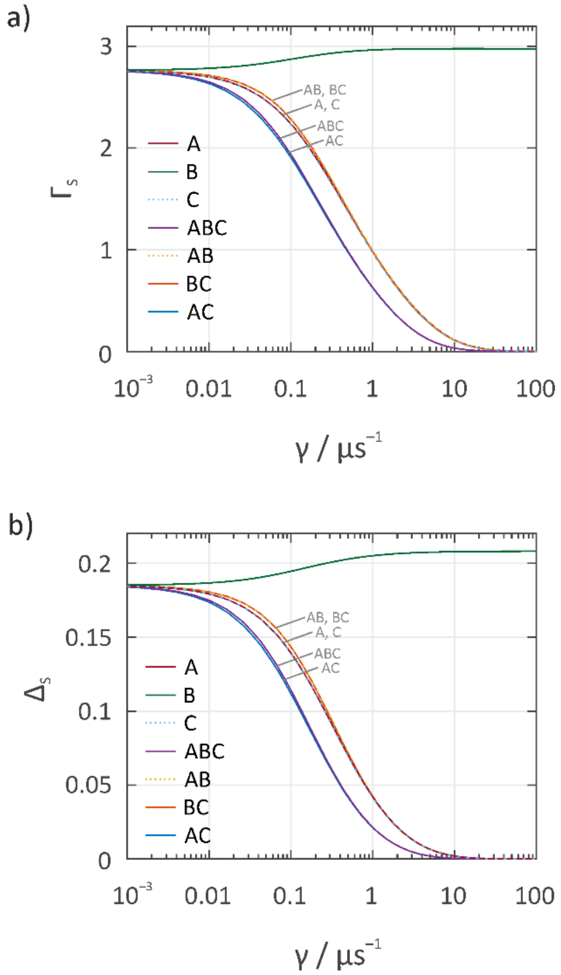

Figure S5: Dependence of Γ_s (a) and Δ_s (b) on the rate of random-field spin relaxation of the electron spins in various radicals of a model [$FAD^{\bullet-}$ $W^{\bullet+}$] radical pair subject to radical scavenging. Pertinent parameters: $\varphi = k_b/k_f = 1$; B_0 = 50 μT; k_f = 0.1 μs^{-1}; k_C = 51.79 μs^{-1}; $A^{\bullet-}$, $B^{\bullet+}$ and $C^{\bullet}$ comprised N5 and N10 of $FAD^{\bullet-}$, N1 of $W_C^{\bullet+}$ and no magnetic nuclei, respectively.

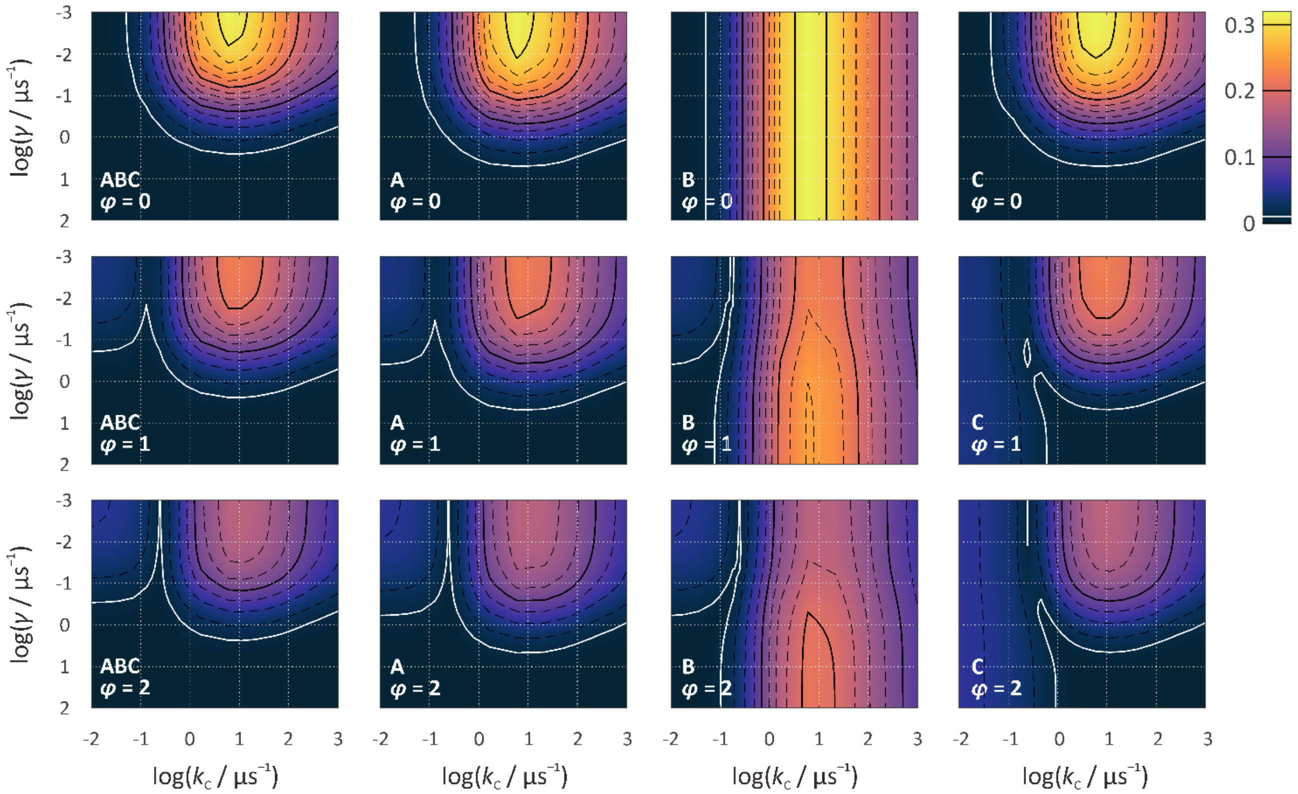

Figure S6: Contour plots of Δ_S as a function of k_C and γ for three different φ = 0, 1, and 2 (*rows*) and random field relaxation in all three radicals (*left*) or either A, B, or C (*right*). The white and the (up to) three solid black contour lines corresponds to 1 %, 10%, 20% and 30%, respectively. The 1 % contour is used in the main text to discuss the resilience of the compass to spin relaxation. $A^{\bullet -}$, $B^{\bullet +}$ and $C^{\bullet}$ comprised N5 and N10 of $FAD^{\bullet -}$, N1 of $W_C^{\bullet +}$ and no magnetic nuclei, respectively. All simulation parameters were the same as for Figure 2 of the main manuscript.

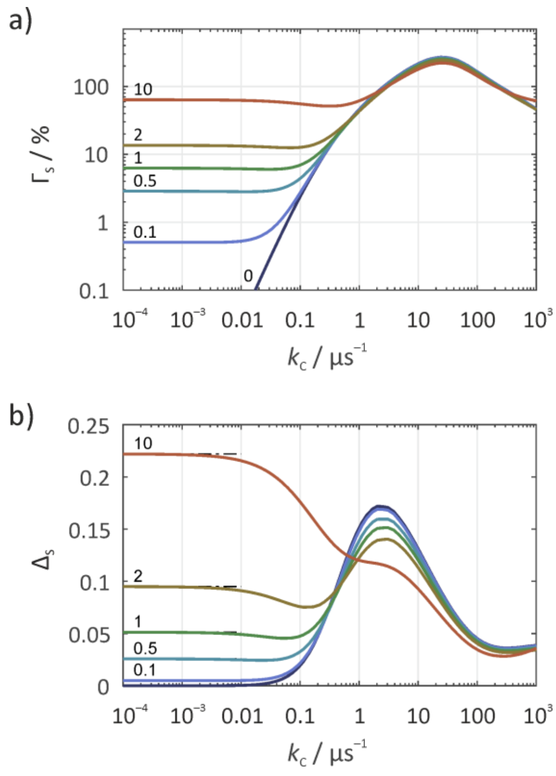

Figure S7: Anisotropic yields of the signalling state for a triplet-born [FAD$^{\bullet-}$ Z$^{\bullet}$] radical pair subject to radical scavenging. *a)* relative anisotropy (Γ_S), *b)* absolute anisotropy (Δ_S), both as a function of the scavenging rate constant, k_C, for various values of ϕ (indicated in the figure). The radical triad comprised N5, N10, H6, H8 (3 ×) and Hβ (2 ×) in FAD$^{\bullet-}$ and no hyperfine interactions in Z$^{\bullet}$ or the scavenger. Comparison with calculations for the analogous singlet-born radical pair (see [1]) reveals that for $\phi = 0$, the anisotropy of the singlet states is independent of the initial spin multiplicity. Furthermore, for $\phi = 0$, the maximal $\Gamma_S = 2.7$ occurs at $k_C = 25.4$ μs^{-1}.

1. D. R. Kattnig and P. J. Hore, *Sci. Rep.*, 2017, **7**, 11640.

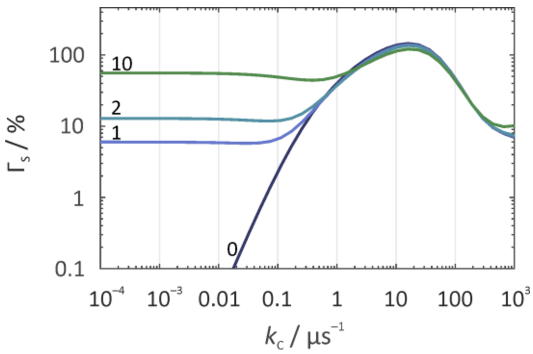

Figure S8: Relative anisotropy of the signalling state for a triplet-born [FADH$^\bullet$ Z$^\bullet$] radical pair subject to radical scavenging. Γ_S is plotted as a function of the scavenging rate constant, k_C, for various values of ϕ (indicated in the figure). The radical triad comprised N5, N10 and H5 in FADH$^\bullet$ and no hyperfine interactions in Z$^\bullet$ or the scavenger. Hyperfine parameters have been taken from [2].

2. A. A. Lee, J. C. S. Lau, H. J. Hogben, T. Biskup, D. R. Kattnig and P. J. Hore, *J. R. Soc. Interface*, 2014, **11**, 20131063.